# 9307

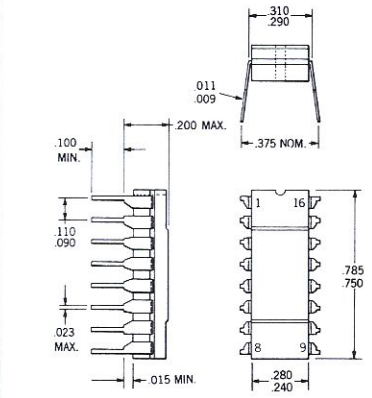
# MSI SEVEN SEGMENT DECODER

## A FAIRCHILD COMPATIBLE CURRENT SINKING LOGIC PRODUCT

**GENERAL DESCRIPTION** — The 9307 is a Seven Segment Decoder designed to accept four inputs in 8421 BCD code and provide the appropriate outputs to drive a seven segment numerical display. The decoder can be used with seven segment incandescent lamp, neon, electro-luminescent, or CRT numeric displays. The 9307 is compatible with all other Fairchild CCSL devices.

- **CCSL COMPATIBLE**
- **AUTOMATIC RIPPLE BLANKING FOR SUPPRESSION OF LEADING EDGE ZEROES**
- **LAMP INTENSITY MODULATION CAPABILITY**
- **LAMP TEST FACILITY**
- **BLANKING INPUT**
- **ACTIVE HIGH OUTPUTS**
- **ALL CERAMIC "HERMETIC" 16 PIN DUAL IN-LINE* PACKAGE**

**PHYSICAL DIMENSIONS**




NOTES:
1. Leads are intended for insertion in hole rows on .300" centers. They are purposely shipped with "positive" (.375) misalignment to facilitate insertion.
2. Board drilling dimensions should equal your practice for a conventional .020 inch diameter lead.

Fig. 1

**LOGIC SYMBOL**

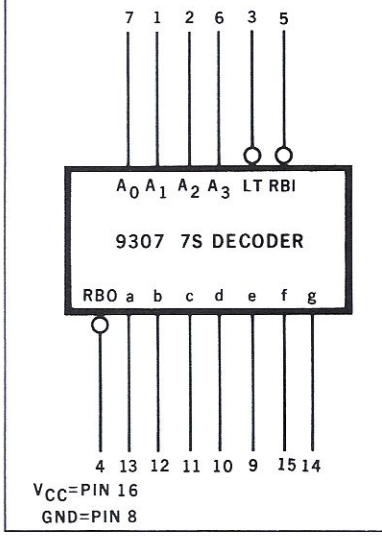



Fig. 2

**ABSOLUTE MAXIMUM RATINGS** (above which the useful life may be impaired)

| | |
|---|---|
| Storage Temperature | −65°C to +150°C |
| Temperature (Ambient) Under Bias | −55°C to +125°C |
| $V_{CC}$ Pin Potential to Ground Pin | −0.5 V to +7 V |
| Voltage Applied to Outputs for high output state | −0.5 V to +$V_{CC}$ value |
| Input Voltage (D.C.) | −0.5 V to +5.5 V |

**ORDER INFORMATION**

Specify U6B9307XXX for 16 pin Dual In-Line package where XXX is 51X for the −55°C to +125°C temperature range, or 59X for the 0°C to +75°C temperature range.

*Fairchild patent pending.

313 FAIRCHILD DRIVE, MOUNTAIN VIEW, CALIFORNIA, (415) 962-5011, TWX: 910-379-6435

FAIRCHILD SEMICONDUCTOR
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

COPYRIGHT FAIRCHILD SEMICONDUCTOR 1968 • PRINTED IN U.S.A. 3435-347-127 30M
MANUFACTURED UNDER ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2981877, 3015048, 3025589, 3064167, 3108359, 3117260; OTHER PATENTS PENDING.

The 9307 seven segment decoder accepts a 4 Bit BCD 8421 code input and produces the appropriate outputs for selection of segments in a seven segment matrix display used for representing the decimal numbers 0 - 9. The seven outputs (a, b, c, d, e, f, g) of the decoder select the corresponding segments in the matrix shown in Figure 3. The numeric designations chosen to represent the decimal numbers are shown in Figure 5, together with the resulting displays for input code configurations in excess of binary nine.

The decoder has active high outputs so that a buffer transistor may be used directly to provide the high currents required for incandescent displays. If additional base drive current is required external resistors may be added from the supply voltage to the seven segment outputs of the decoders. The value of this resistor is constrained by the 10 mA current sinking capability of the output transistors of the circuit.

The device has provision for automatic blanking of the leading and/or trailing edge zeroes in a multidigit decimal number, resulting in an easily readable decimal display, conforming to normal writing practice. In an eight digit mixed integer fraction decimal representation, using the automatic blanking capability, (0060.0300) would be displayed as (60.03). Leading edge zero suppression is obtained by connecting the Ripple Blanking Output (RBO) of a decoder to the Ripple Blanking Input (RBI) of the next lower stage device. The most significant decoder stage should have the RBI input grounded; and, since suppression of the least significant integer zero in a number is not usually desired, the RBI input of this decoder stage should be left open. A similar procedure for the fractional part of a display will provide automatic suppression of trailing edge zeroes.

The decoder has an active low input Lamp Test which overrides all other input combinations and enables a check to be made on possible display malfunctions. The RBO terminal of the decoder can be OR - tied with a modulating signal via an isolating buffer to achieve pulse duration intensity modulation. A suitable signal can be generated for this purpose by forming a variable frequency multivibrator with a cross coupled pair of DTμL gates.

Fig. 3
SEGMENT DESIGNATION

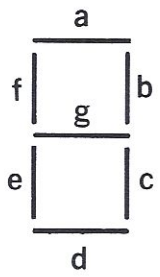



Fig. 4
TRUTH TABLE

| LT | RB IN | A | B | C | D | a | b | c | d | e | f | g | RB OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L | X | X | X | X | X | H | H | H | H | H | H | H | H | |
| H | L | L | L | L | L | L | L | L | L | L | L | L | L | 0 |
| H | H | L | L | L | L | H | H | H | H | H | H | L | H | 0 |
| \| | X | H | L | L | L | L | H | H | L | L | L | L | H | 1 |
| \| | \| | L | H | L | L | H | H | L | H | H | L | H | H | 2 |
| \| | \| | H | H | L | L | H | H | H | H | L | L | H | H | 3 |
| \| | \| | L | L | H | L | L | H | H | L | L | H | H | H | 4 |
| \| | \| | H | L | H | L | H | L | H | H | L | H | H | H | 5 |
| \| | \| | L | H | H | L | H | L | H | H | H | H | H | H | 6 |
| \| | \| | H | H | H | L | H | H | H | L | L | L | L | H | 7 |
| \| | \| | L | L | L | H | H | H | H | H | H | H | H | H | 8 |
| \| | \| | H | L | L | H | H | H | H | H | L | H | H | H | 9 |
| \| | \| | L | H | L | H | L | L | L | H | H | L | H | H | 10 |
| \| | \| | H | H | L | H | L | L | L | H | L | L | H | H | 11 |
| \| | \| | L | L | H | H | L | H | H | L | L | H | H | H | 12 |
| \| | \| | H | L | H | H | H | L | H | H | L | H | H | H | 13 |
| \| | \| | L | H | H | H | L | L | L | H | H | H | H | H | 14 |
| H | X | H | H | H | H | L | L | L | L | L | L | L | H | 15 |

H = HIGH VOLTAGE LEVEL
L = LOW VOLTAGE LEVEL

Fig. 5
NUMERICAL DESIGNATIONS

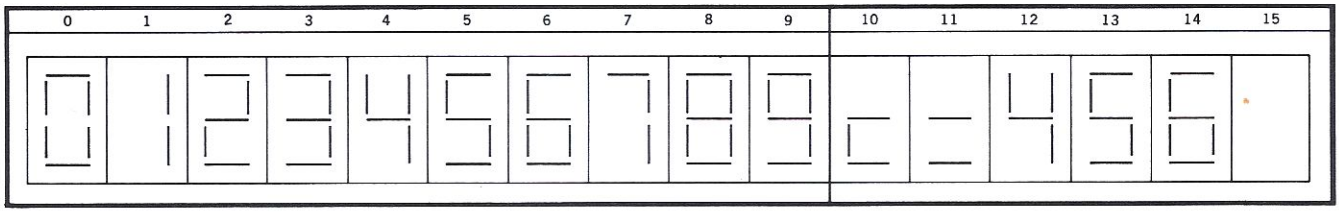



Table 1—Loading Rules (1 U.L. = 1 DTμL Gate Input Load)

| Inputs | Loading (51X & 59X) | |
|---|---|---|
| | High State | Low State |
| $A_0$, $A_1$, $A_2$, $A_3$ | 1 | 1 |
| $R_{B(IN)}$ | 1 | ½ |
| LT | 5 | 4.3 |

| Outputs | Fan Out | |
|---|---|---|
| | 51X | 59X |
| a, b, c, d, e, f, g | 8 | 7 |
| $R_{B(OUT)}$ | 2.0 | 1.5 |

**TABLE II —**
**ELECTRICAL CHARACTERISTICS** ($T_A = -55°C$ to $+125°C$, $V_{CC} = 5.0\ V \pm 10\%$) (Part #U6B930751X)

| SYMBOL | CHARACTERISTICS | LIMITS −55°C MIN. | LIMITS −55°C MAX. | LIMITS +25°C MIN. | LIMITS +25°C TYP. | LIMITS +25°C MAX. | LIMITS +125°C MIN. | LIMITS +125°C MAX. | UNITS | CONDITIONS |
|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OH}$ | Output High Voltage | 4.3<br>3.0 | | 4.3<br>3.0 | 4.4<br>4.0 | | 4.4<br>3.0 | | Volts | $V_{CC} = 4.5\ V$ $I_{OH} = 0.0\ mA$ (Pins 9-15)<br>$V_{CC} = 4.5\ V$ $I_{OH} = -70\ \mu A$ (Pin 4)<br>Inputs at threshold voltages ($V_{IL}$ or $V_{IH}$) |
| $V_{OL}$ | Output Low Voltage | | 0.4 | | 0.21 | 0.4 | | 0.4 | Volts | $V_{CC} = 5.5\ V$ $I_{OL} = 12.5\ mA$ (Pins 9-15)<br>$I_{OL} = 3.1\ mA$ (Pin 4)<br>$V_{CC} = 4.5\ V$ $I_{OL} = 10\ mA$ (Pins 9-15)<br>$I_{OL} = 2.4\ mA$ (Pin 4)<br>Inputs at threshold voltages ($V_{IL}$ or $V_{IH}$) |
| $V_{IH}$ | Input High Voltage | 2.1 | | 1.9 | | | 1.7 | | Volts | Guaranteed input high threshold for all inputs |
| $V_{IL}$ | Input Low Voltage | | 1.4 | | | 1.1 | | 0.8 | Volts | Guaranteed input low threshold for all inputs |
| $I_F$ (Pin 3)<br>$I_F$ (Pins 1, 2, 6, 7)<br>$I_F$ (Pin 5) | Input Load Current<br>Input Load Current<br>Input Load Current | | −6.4<br>−1.5<br>−0.75 | | | −6.4<br>−1.5<br>−0.75 | | −6.4<br>−1.5<br>−0.75 | mA | $V_{CC} = 5.5\ V$ $V_F = 0.4\ V$<br>$V_R = 5.5\ V$ on other inputs |
| $I_R$ (Pin 3)<br>$I_R$ (Pins 1, 2, 5, 6, 7) | Input Leakage Current<br>Input Leakage Current | | | | | 10<br>2.0 | | 25<br>5.0 | μA | $V_{CC} = 5.5\ V$ $V_R = 4.5\ V$<br>Ground on other inputs |
| $I_A$ (Pins 9-15) | Available Output Current | −1.4 | | −1.4 | | | −1.0 | | mA | $V_{OUT} = 0.85\ V$ $V_{CC} = 4.5\ V$<br>Inputs at threshold voltages ($V_{IL}$ or $V_{IH}$) |
| $I_{SC}$ (Pins 9-15) | Short Circuit Current | | | | | −3.7 | | | mA | $V_{OUT} = 0.0\ V$ $V_{CC} = 5.5\ V$ |
| $t_{pd+}$ | Switching Speed | | | | | 500 | | | ns | $V_{CC} = 5.0\ V$, See Figure 6 |
| $t_{pd-}$ | Switching Speed | | | | | 500 | | | ns | |

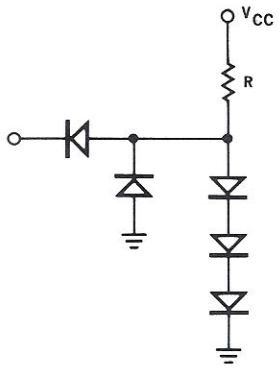
**TABLE III —**
**ELECTRICAL CHARACTERISTICS** ($T_A = 0°C$ to $+75°C$, $V_{CC} = 5.0\ V \pm 5\%$) (Part #U6B930759X)

| SYMBOL | CHARACTERISTICS | LIMITS 0°C MIN. | LIMITS 0°C MAX. | LIMITS +25°C MIN. | LIMITS +25°C TYP. | LIMITS +25°C MAX. | LIMITS +75°C MIN. | LIMITS +75°C MAX. | UNITS | CONDITIONS |
|---|---|---|---|---|---|---|---|---|---|---|
| $V_{OH}$ | Output High Voltage | 4.3<br>2.7 | | 4.3<br>2.7 | 4.6<br>4.0 | | 4.3<br>2.7 | | Volts | $V_{CC} = 4.75\ V$ $I_{OH} = 0.0\ mA$ (Pins 9-15)<br>$V_{CC} = 4.75\ V$ $I_{OH} = -70\ \mu A$ (Pin 4)<br>Inputs at threshold voltages ($V_{IL}$ or $V_{IH}$) |
| $V_{OL}$ | Output Low Voltage | | 0.45 | | 0.21 | 0.45 | | 0.45 | Volts | $V_{CC} = 5.25\ V$ $I_{OL} = 11.5\ mA$ (Pins 9-15)<br>$I_{OL} = 2.75\ mA$ (Pin 4)<br>$V_{CC} = 4.75\ V$ $I_{OL} = 10\ mA$ (Pins 9-15)<br>$I_{OL} = 2.4\ mA$ (Pin 4)<br>Inputs at threshold voltages ($V_{IL}$ or $V_{IH}$) |
| $V_{IH}$ | Input High Voltage | 2.0 | | 2.0 | | | 2.0 | | Volts | Guaranteed input high threshold for all inputs |
| $V_{IL}$ | Input Low Voltage | | 0.85 | | | 0.85 | | 0.85 | Volts | Guaranteed input low threshold for all inputs |
| $I_F$ (Pin 3)<br>$I_F$ (Pins 1, 2, 6, 7)<br>$I_F$ (Pin 5) | Input Load Current<br>Input Load Current<br>Input Load Current | | −6.4<br>−1.5<br>−0.75 | | | −6.4<br>−1.5<br>−0.75 | | −6.4<br>−1.5<br>−0.75 | mA | $V_{CC} = 5.25\ V$ $V_F = 0.45\ V$<br>$V_R = 5.25$ on other inputs |
| $I_R$ (Pin 3)<br>$I_R$ (Pins 1, 2, 5, 6, 7) | Input Leakage Current<br>Input Leakage Current | | | | | 25<br>5.0 | | 50<br>10 | μA | $V_{CC} = 5.25\ V$ $V_R = 4.5\ V$<br>Ground on other inputs |
| $I_A$ (Pins 9-15) | Available Output Current | −1.4 | | −1.4 | | | −1.0 | | mA | $V_{OUT} = 0.75\ V$ $V_{CC} = 4.75\ V$<br>Inputs at threshold voltages ($V_{IL}$ or $V_{IH}$) |
| $I_{SC}$ (Pins 9-15) | Short Circuit Current | | | | | −4.0 | | | mA | $V_{OUT} = 0.0\ V$ $V_{CC} = 5.5\ V$ |
| $t_{pd+}$ | Switching Speed | | | | | 500 | | | ns | $V_{CC} = 5.0\ V$, See Figure 6 |
| $t_{pd-}$ | Switching Speed | | | | | 500 | | | ns | |

## TYPICAL INPUT AND OUTPUT CHARACTERISTICS

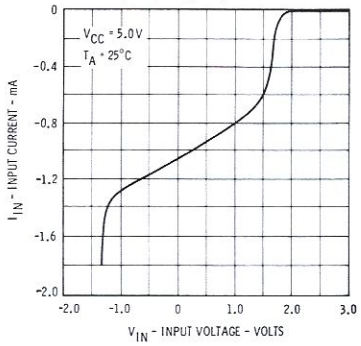
### INPUTS

#### Equivalent Circuit

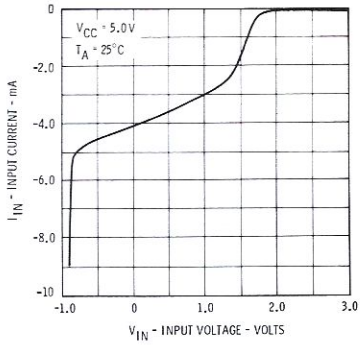



### INPUT CURRENT VERSUS INPUT VOLTAGE

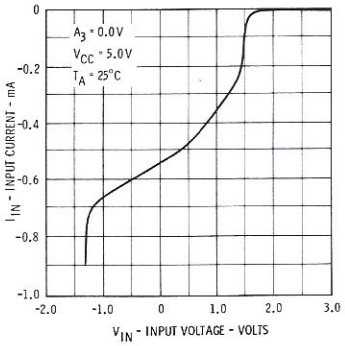
#### $A_0$, $A_1$, $A_2$, $A_3$ INPUTS




#### LT INPUT



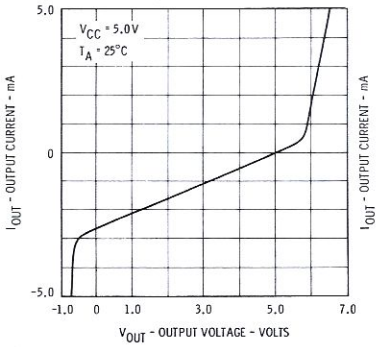

#### $RB_{(IN)}$ INPUT



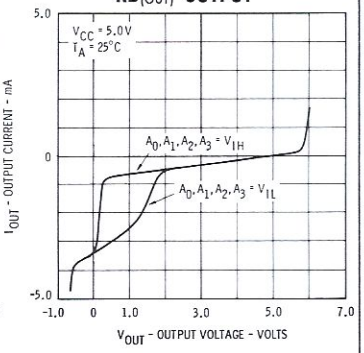

### OUTPUT CURRENT VERSUS OUTPUT VOLTAGE

#### U6B930751X (—55°C to +125°C) OUTPUT IN HIGH STATE

##### a, b, c, d, e, f, g OUTPUTS

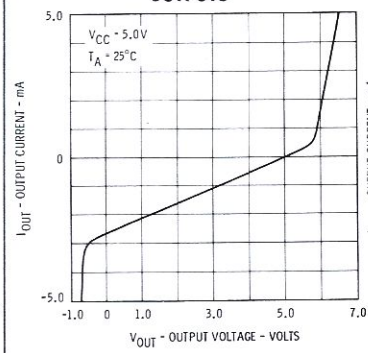



##### $RB_{(OUT)}$ OUTPUT

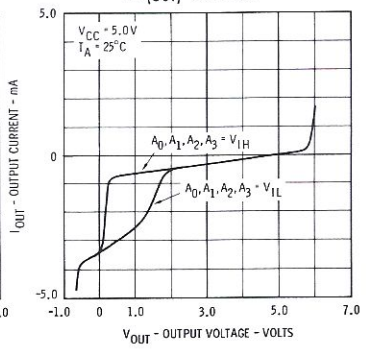



#### U6B930759X (0°C to +75°C) OUTPUT IN HIGH STATE

##### a, b, c, d, e, f, g OUTPUTS

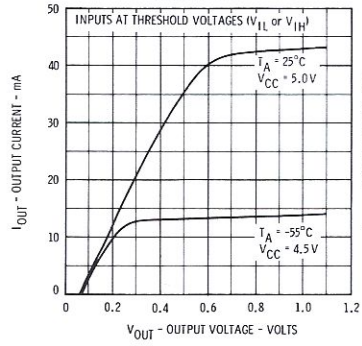



##### $RB_{(OUT)}$ OUTPUT

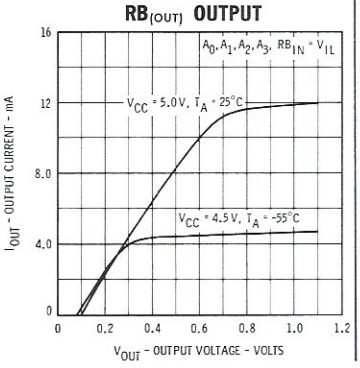



#### OUTPUT IN LOW STATE

##### a, b, c, d, e, f, g OUTPUTS

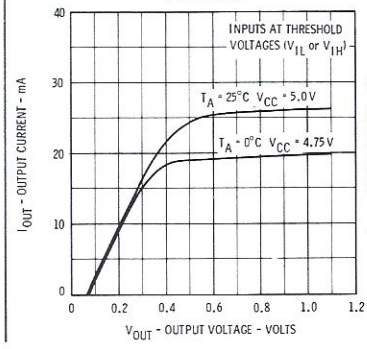



##### $RB_{(OUT)}$ OUTPUT

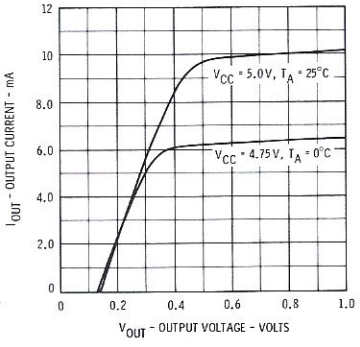



#### OUTPUT IN LOW STATE

##### a, b, c, d, e, f, g OUTPUTS

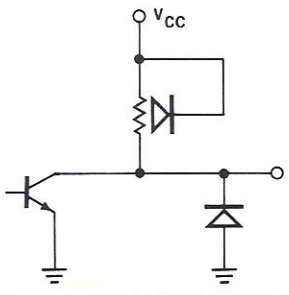



##### $RB_{(OUT)}$ OUTPUT

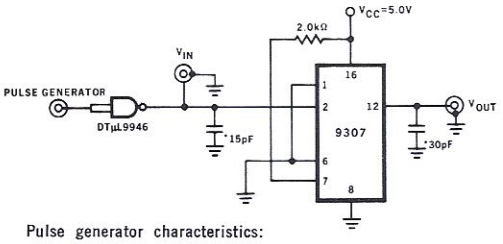



### OUTPUTS

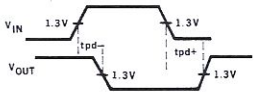
#### Equivalent Circuit



### Fig. 6—SWITCHING CIRCUIT AND WAVEFORMS




Pulse generator characteristics:
Amptitude = 3.0 V
Freq. = 500 kHz
Pulse width = 1000 ns
$t_r = t_f \leq 15$ ns
*Includes probe and jig capacitance




## APPLICATIONS

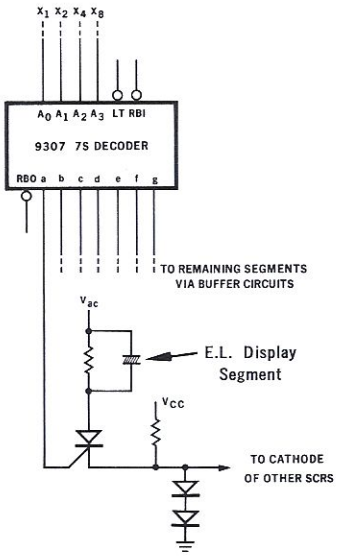



**Fig. 7**
9307 Seven Segment Decoder driving Electro-Luminescent Display.

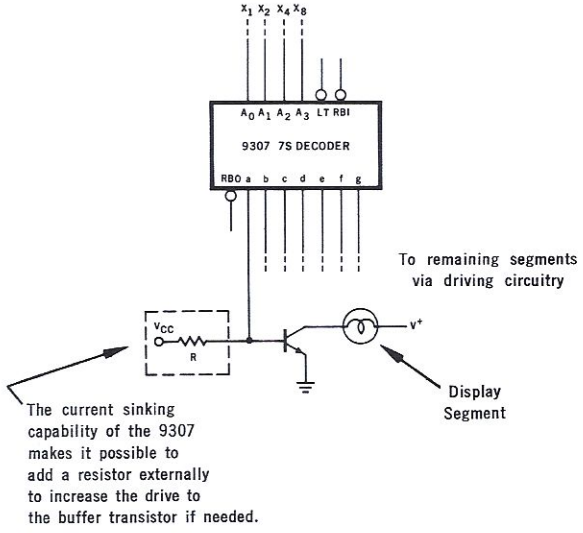
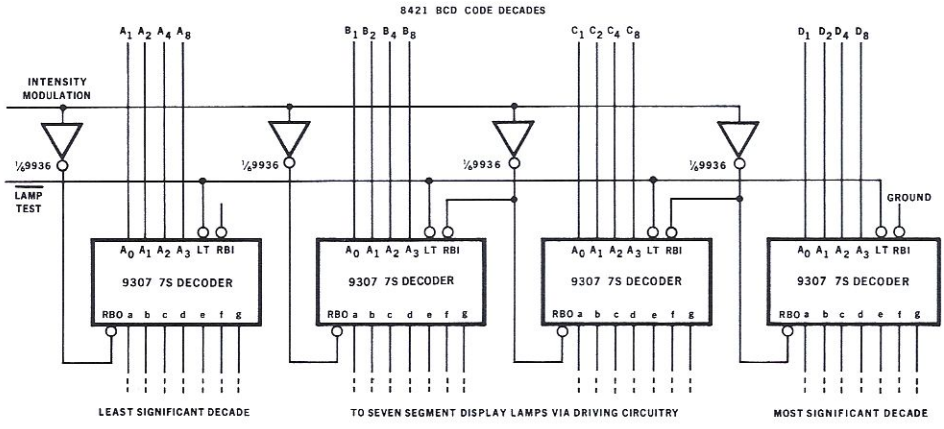



**Fig. 8**
9307 Seven Segment Decoder driving Incandescent lamp Display.




### Fig. 9—FOUR DECADE SEVEN SEGMENT INTEGER DISPLAY SCHEME

This scheme incorporates automatic blanking of leading edge zeroes and intensity modulation using an external variable duty cycle signal.

FAIRCHILD
SEMICONDUCTOR
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

Fairchild cannot assume responsibility for use of any circuitry described other than circuitry entirely embodied in a Fairchild product. No other circuit patent licenses are implied.